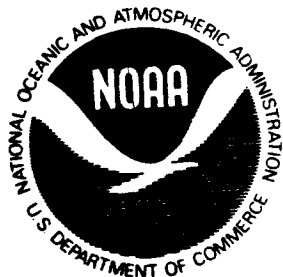


170.72
NOAA Technical Memorandum

NMFS-SEFC-12



RESULTS OF A KING MACKEREL (SCOMBEROMORUS CAVALLA) AND
ATLANTIC SPANISH MACKEREL (SCOMBEROMORUS MACULATUS)
MIGRATION STUDY, 1975-79

Doyle F. Sutherland

William A. Fable, Jr.

March 1980

U.S. DEPARTMENT OF COMMERCE
Philip M Klutznick, Secretary
National Oceanic and Atmospheric Administration
Richard A. Frank, Administrator
National Marine Fisheries Service
Terry L. Leitzell, Assistant Administrator for Fisheries

This TM series is used for documentation and timely communication of preliminary results, interim reports, or similar special purpose information. Although the memos are not subject to complete formal review, editorial control, or detailed editing, they are expected to reflect sound professional work.

ABSTRACT

The Panama City and Port Aransas Laboratories tagged and released 2,731 king and 745 Atlantic Spanish mackerel in a 1975-78 study of their movements and migration. From those releases, 59 (2.2%) of the king mackerel and 44 (5.9%) of the Atlantic Spanish mackerel were subsequently recaptured.

The tagged recoveries revealed an annual migration by king mackerel from south Florida waters north to the northeast coast of the Gulf of Mexico and west to south Texas waters in the spring and return to south Florida in the fall. Mixing of Gulf fish in the winter with Atlantic fish north to Ft. Pierce was disclosed by tagged recaptures.

Fragmented evidence was obtained that Atlantic Spanish mackerel make an annual migration from wintering grounds off south Florida and Campeche-Yucatan to summer grounds along the northern Gulf coast and a return migration in the fall.

KING MACKEREL

INTRODUCTION

In 1975 the National Marine Fisheries Service laboratories in Beaufort, North Carolina, Panama City, Florida, and Port Aransas, Texas, together with the southeast Atlantic and Gulf of Mexico (Gulf) states began a study of the movements and migrations of king mackerel (Scomberomorus cavalla) and Atlantic Spanish mackerel (S. maculatus) by the tag-recapture method. This paper reports the results of this study by the National Marine Fisheries Service laboratories in years 1975-79.

The king mackerel was reported to range as far north as Cape Cod in the North Atlantic (Latham, 1919; Bigelow and Schroeder, 1953), and as far south as Brazil, and east to Africa in the tropical Atlantic (Jordan, Everman, and Clark, 1930). Later reviewers make no reference to their occurrence in Africa (Collette and Russo, 1979). Their common occurrence in coastal waters from Florida to Texas was noted by Baughman (1950). Briggs (1958) extended the range to include the entire Gulf and possibly the western Caribbean. Their presence in the eastern Caribbean among the Antillian Islands was previously noted by Erdman (1949).

The king mackerel is one of the more important pelagic food and sport fishes found along the south Atlantic and Gulf coasts of the U.S. Deuel (1973) estimated sportsmen caught 34,942,000 and 27,459,000 lbs in those two areas in 1970. The commercial catch in comparison amounted, respectively, to 4,351,000 and 2,372,000 lbs. The declining catch in recent years has caused great concern among fishermen and the resource managers. By 1975 the anglers catch was estimated at 11,942,000 lbs, representing a decline of 81% from the 1970 catch, and the commercial catch at 6,823,000 lbs, an increase of 1% (Fish. Stat. of the U.S., 1970; Fisheries of the United States, 1976, 1978).

The coastal waters from Jupiter Inlet on Florida's east coast south to the Keys and north to Naples on the west coast is recognized as important

wintering grounds for king mackerel. While concentrated in that area the fish are heavily exploited by commercial and sport fishermen (Beaumariage, 1973). The fish usually begin their spring migration northward along both coasts in April (Moe, 1966). The fish are commonly referred to as the Atlantic and Gulf stocks based solely on their seasonal geographical separation rather than a known biological difference.

MATERIALS AND METHODS

Very little information on king mackerel tagging was available prior to this study to suggest either an appropriate tag or an efficient tagging method. In tagging experiments conducted by the Florida Department of Natural Resources in 1963-65, 640 king mackerel were tagged with the California spaghetti tag and 47 with a body cavity or internal anchor tag. Of the 687 fish only 3 with the spaghetti tag were subsequently recaptured (Beaumariage, 1964, 1969; Beaumariage and Wittick, 1966; Moe, 1966). Fry and Roedel (1949) found that the Pacific mackerel, Pneumatophorus diego, suffered an average minimum mortality of 23% when tagged with a body cavity tag and an average maximum mortality of 57% from all causes, including tag loss.

In this study one tag and two experimental tagging methods were used. An all-plastic dart tag (Floy Tag and Mfg., Inc. No. FT-1) was selected for the reasons and results reported by Yamashita and Waldron (1958) and to minimize tagging mortality. Further, its ease of application was given special consideration, for anglers, students, and untrained biologists participated in the tagging effort.

The method of tagging and handling the fish in the initial (1975) experiment conducted by personnel of the Panama City Laboratory was similar to that used to tag large fish such as billfish, tunas, and shark. That is, the fish after being caught by hook and line, was brought alongside the boat and tagged while still in the water. The tag was inserted by means of a tagging needle attached to the end of a 1.2 m pole. The tagger attempted to place the tag in the musculature below the origin of the second dorsal fin to a depth sufficient to allow the barb of the tag to hook a pterygiophore when the needle was withdrawn. Immediately after applying the tag the fish was lifted by the leader to within reach and freed by cutting the leader close to the hook.

In subsequent years the handling method was changed; fish were brought aboard for tagging. V-shaped plywood troughs 100 cm long, 45 cm wide, and 40 cm deep were used by personnel of the Panama City Laboratory to confine the fish for dehooking and tagging. A hinged plywood cover fitted to the top of the trough was used to physically restrain robust fish and to calm them by the semi-darkness. To further minimize fish distress and injury, the box was filled with water to a depth of about 18 cm. Fish larger than 100 cm were tagged on the boat deck. Personnel of the Port Aransas Laboratory and participating anglers tagged all fish on the boat deck or in a dry tagging cradle. The tagging pole was shortened to about 22 cm and the tag inserted as previously described.

RESULTS AND DISCUSSION

In the initial tagging experiment (1975) 1,106 king mackerel were tagged off Panama City by the big-game-fish tagging method. None of those fish were recaptured, indicating rather conclusively that the tagging method was unsuitable. Of the possible reasons for the negative results, failure to implant the tag properly by the tagger was suspected to be most important. Over-eagerness to tag the fish before it escaped the hook, a small target area, and the movement of the fish and the boat in the water contributed to the misplants. Dangling hooks in the fish's mouth may have contributed to an apparently high tagging mortality rate.

Tag failure may also have contributed to the negative results, as indicated in a tagging experiment by personnel of the Florida Department of Natural Resources (R. O. Williams, personal communication). During the period 28 April - 7 June 1976, 1,356 king mackerel were alternately tagged with dart and internal anchor tags. After 120 days 13 dart and 10 internal anchor tags were recovered. However, after 480 days the total recoveries were 14 dart and 37 internal anchor tags. The difference was highly significant statistically ($\chi^2 = 10.44$, $P < 0.01$; Snedecor and Cochran, 1967). A breakdown of the adhesive used to bond the two-piece dart tag by prolonged exposure to ambient subtropic air and water temperatures was the probable cause of tag failure.

The numbers of tagged king mackerel that were released and recovered in years 1975-1978 are listed in Table 1. Data pertaining to individual fish are summarized in Appendix Table 1. The release/recovery locations for individual fish are shown in Figures 1-5 by year of release, number of days out, traveled distance, and theoretical migratory route.

Table 1. Number of king mackerel tagged and recaptured by year released, 1975-78.

Year	Laboratory								
	Panama City			Port Aransas			Beaufort		
	Tagged	Recaptured	%	Tagged	Recaptured	%	Tagged	Recaptured	%
1975	1,106	0	0.0	282	3	1.1	0	0	0.0
1976	358	10	2.8	252	1	0.4	50	0	0.0
1977	395	15	3.9	236	1	0.4	16	0	0.0
1978	102	2	2.0	0	0	0.0	108	0	0.0

March releases (Figure 1)

The spring migration of king mackerel is a highly publicized event. Fishermen and the public along the eastern and northern Gulf coasts are advised daily about the migrations through person to person radio communications and the news media. The tag recovery data (Appendix Table 1) indicate that the king mackerel are concentrated in the Florida Keys during December through

mid-March and in the Naples area in April. In some years the main run may reach the St. Petersburg-Tampa area in April and the Cape San Blas-Destin area in May. In other years the migration may be westerly across the Gulf from the Naples-Ft. Myers area. The 1977-1978 runs failed to reach the St. Petersburg-Tampa area or the Cape San Blas-Destin area in substantial numbers (R. O. Williams, Florida Department of Natural Resources, personal communications).

The Texas coastal waters may be the destination of many of the migrants as indicated by the recapture on 10 July 1977 of a king mackerel released off Naples on 20 March 1977. Its average minimum migration rate was 13.3 km (7.2 mi.) per day, and suggests that the migratory route may have been direct from release site to recapture site.

May releases (Figure 2)

Spring migrant king mackerel may appear in coastal waters off Panama City in late April (Sutherland, 1977). The main run, however, usually does not arrive until late May or early June, reaches peak abundance in June and declines in July and August. Their summer destination was not determined, although the recapture off Texas of the fish previously mentioned suggests that some of the fish continue westward across the northern Gulf. The recapture of one fish, which had been tagged and released off Panama City in May 1976, on the winter ground off south Florida in February 1977 further suggests a late fall or early winter return migration.

June, July, and August releases (Figure 3)

King mackerel apparently end their westward migration along the northern Gulf in the June-July period. The recapture in coastal waters off west Texas in July of the tagged fish that was released off Naples in March (Figure 1) provides substantiating evidence. Additionally, those tagged fish released and recaptured along the northern Gulf coast in the June-August period showed little movement. Of those 9 recaptured fish 6 showed virtually no movement after 7- days of freedom, and the others no more than 185 km (100 mi.) in 18 days.

Migration of king mackerel in the fall from their summer feeding grounds in the northwest Gulf to their winter feeding grounds off south Florida was confirmed by the recapture of two tagged fish. One of the fish was tagged off Port Mansfield on 21 August 1976 and recaptured off Key West in April 1977. The exact date and location of recapture could not be determined, because the tagged fish was discovered in the Fulton Fish Market, New York, in a commercial shipment from Key West. The other king mackerel was tagged off Freeport on 29 July 1978 and recaptured off Key West on 1 January 1979.

September releases (Figure 4)

The fall migration of king mackerel from the northeast Gulf coast to south Florida waters has been conclusively established by this study. In two successive years 1976-77, fish tagged off Panama City in September were recaptured in the winter fishery off south Florida. The recapture off

Ft. Pierce on 29 December 1977 of a 63 cm fish that was tagged off Panama City on 14 September 1977 gave direct evidence of movement from Gulf waters to south Atlantic waters. That fish traveled a minimum of 1,222 km (660 mi.) in 107 days for an average migration rate of 11.4 km (6.2 mi.) per day.

The west to east king mackerel fall migration across the northern Gulf as indicated by fish numbers 14 and 31, Figure 3, usually reaches its peak by mid-September in the Panama City area. Tag recapture data indicate that some of those fish remain in this area for several days and others proceed slowly southward. One fish showed little movement in 11 days after release and 6 averaged a minimum of only 5.2 km (2.8 mi.) enroute to the Key West-Marathon area. An inshore-offshore movement of some king mackerel may occur in the fall also.

October releases (Figure 5)

The fall migration of king mackerel continues through October in the northeast Gulf. The migratory pattern of those fish that were tagged and released off Panama City in October was almost identical to the September pattern. Of the 7 recaptures one showed little movement after 28 days, 5 were recaptured in the winter fishery off southwest Florida from 134 to 181 days later, and one was recaptured off Ft. Pierce in south Atlantic waters 147 days later.

The migratory rates of the October releases were slightly lower than the September releases. Those fish recaptured off southwest Florida averaged a minimum of 4.4 km (2.4 mi.) per day compared to 5.2 km (2.8 mi.) per day for September releases. The fish recaptured off Ft. Pierce averaged 5.4 km (2.0 mi.) per day compared to 5.9 km (3.2 mi.) per day by the September releases.

Other releases

While the tag release-return data presented above strongly indicate a southeast-northwest migration of king mackerel in the spring and a return migration in the fall, apparently, not all king mackerel join the annual cycle. There is a growing amount of evidence to suggest an inshore-offshore migration by some of the older, larger fish. Fish weighing over 14 kg are caught in modest numbers by anglers fishing Louisiana's offshore waters in all months. The fish reportedly reach peak availability in the winter and early spring period--December through April. Accounts of this sport fishery are occasionally featured in popular saltwater fishing magazines. King mackerel of comparable size are infrequently caught elsewhere in the winter months along the northern Gulf coast to indicate further that king mackerel may over-winter locally in deep water.

Efforts to catch, tag, and release those fish off Louisiana by personnel of the Panama City Laboratory, Louisiana's Grand Isle Laboratory, and members of the New Orleans Big Game Fishing Club have been relatively unsuccessful. Because of the time, expense, and low catch rate, less than 100 fish were tagged and released. None of those fish have been recovered to date.

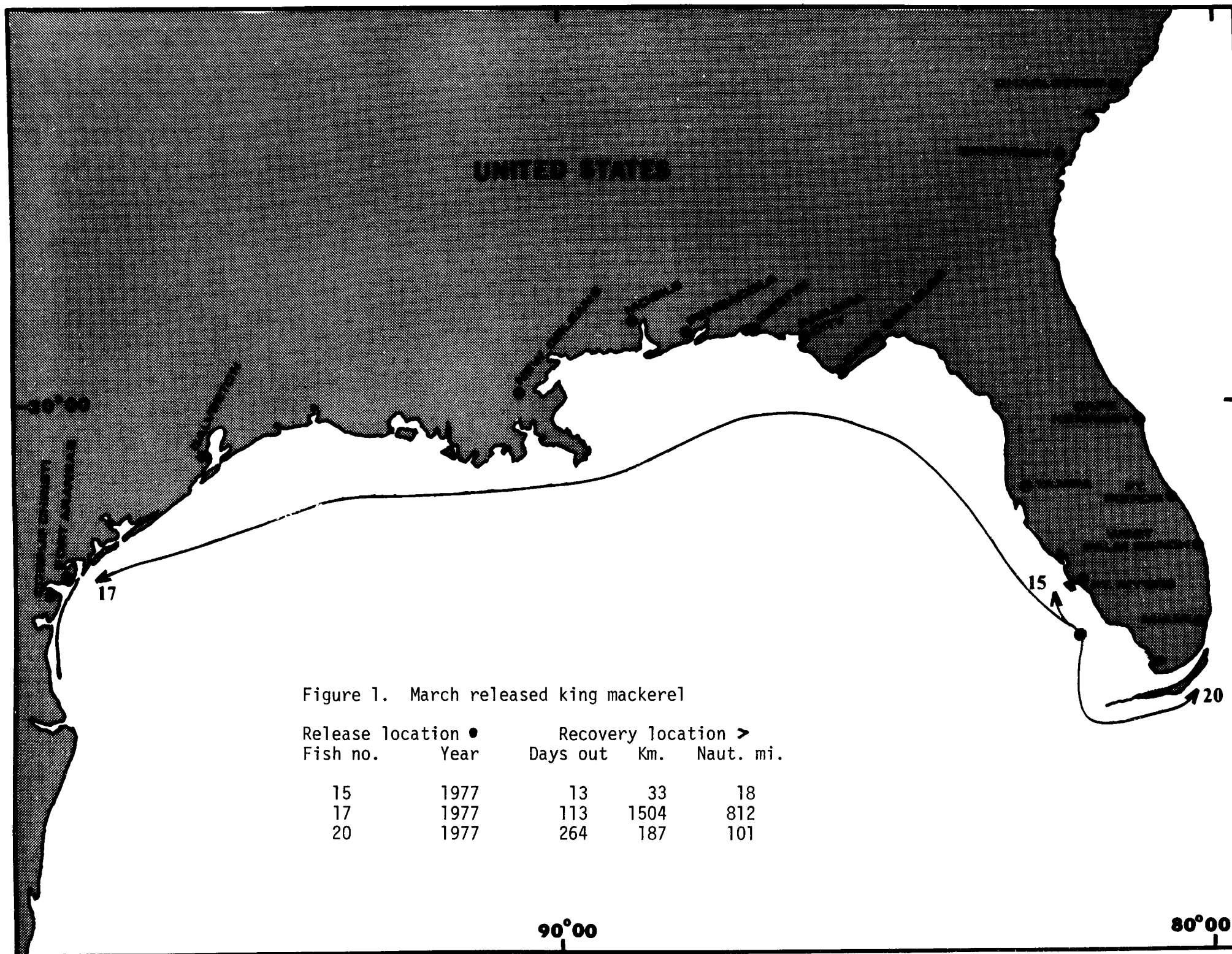


Figure 1. March released king mackerel

Release location ●		Recovery location >		
Fish no.	Year	Days out	Km.	Naut. mi.
15	1977	13	33	18
17	1977	113	1504	812
20	1977	264	187	101

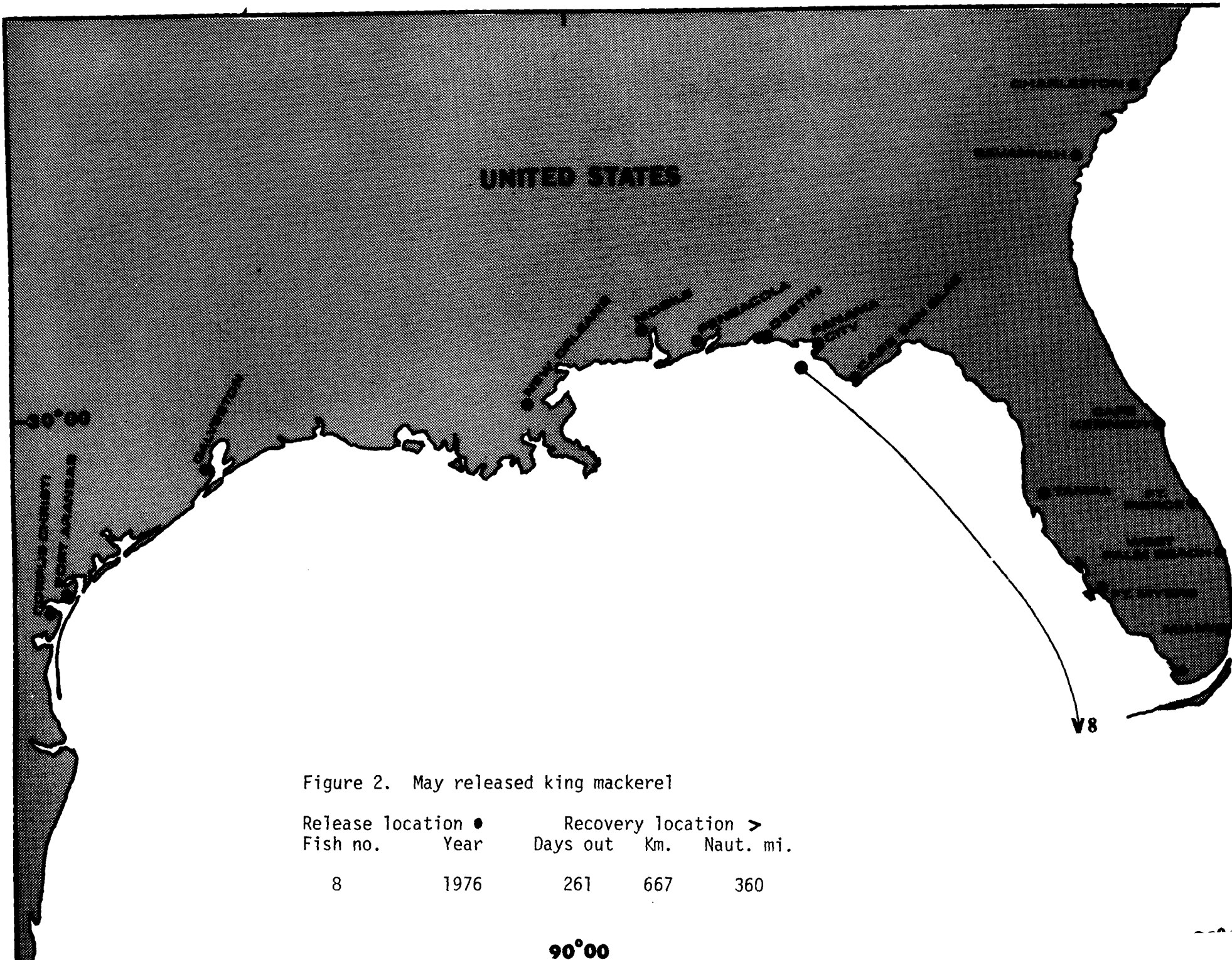


Figure 2. May released king mackerel

Release location •		Recovery location >		
Fish no.	Year	Days out	Km.	Naut. mi.
8	1976	261	667	360

90°00

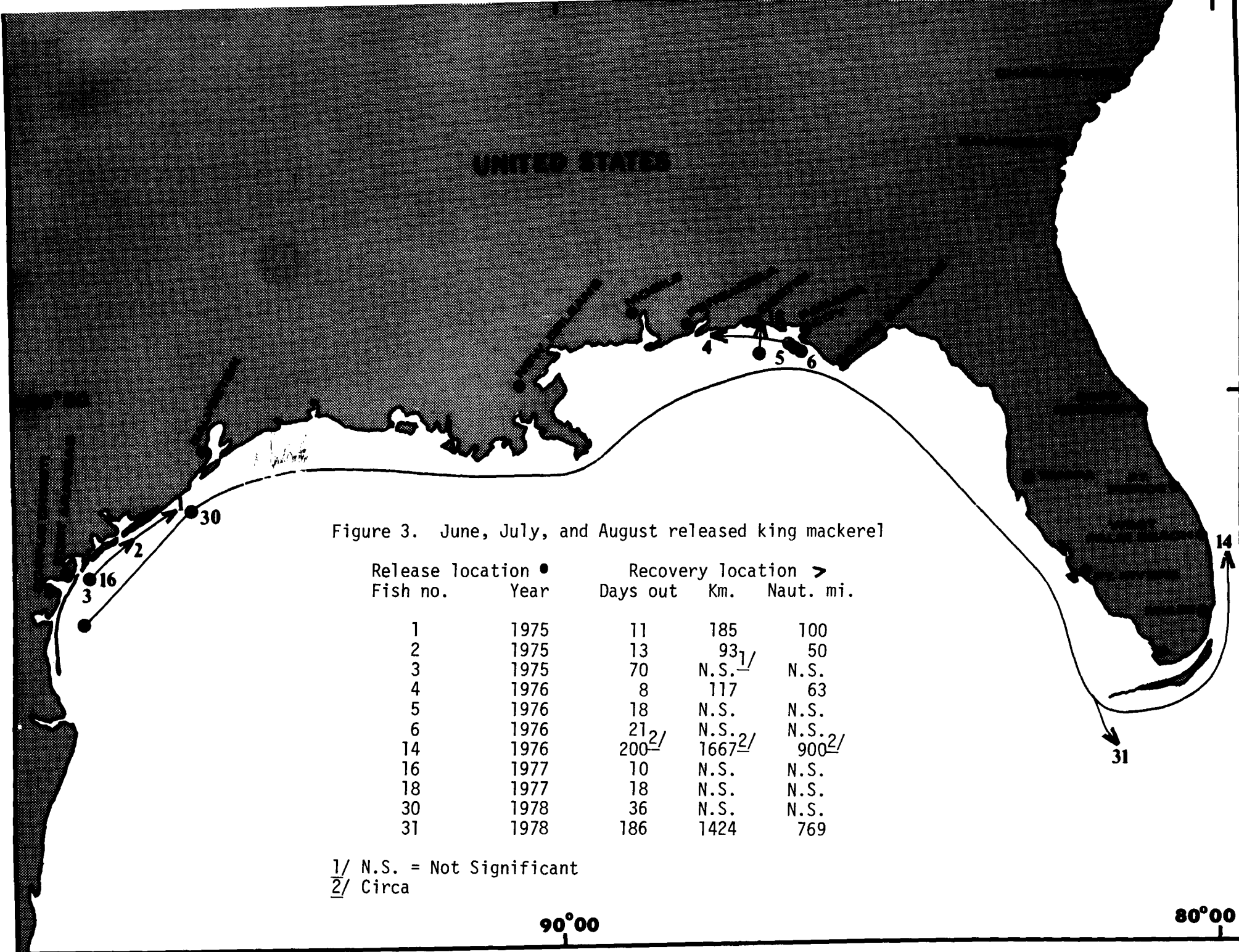


Figure 3. June, July, and August released king mackerel

Release location •		Recovery location >		
Fish no.	Year	Days out	Km.	Naut. mi.
1	1975	11	185	100
2	1975	13	93 ^{1/}	50
3	1975	70	N.S. ^{1/}	N.S.
4	1976	8	117	63
5	1976	18	N.S.	N.S.
6	1976	21 ^{2/}	N.S. ^{2/}	N.S. ^{2/}
14	1976	200 ^{2/}	1667 ^{2/}	900 ^{2/}
16	1977	10	N.S.	N.S.
18	1977	18	N.S.	N.S.
30	1978	36	N.S.	N.S.
31	1978	186	1424	769

^{1/} N.S. = Not Significant

^{2/} Circa

90°00

80°00

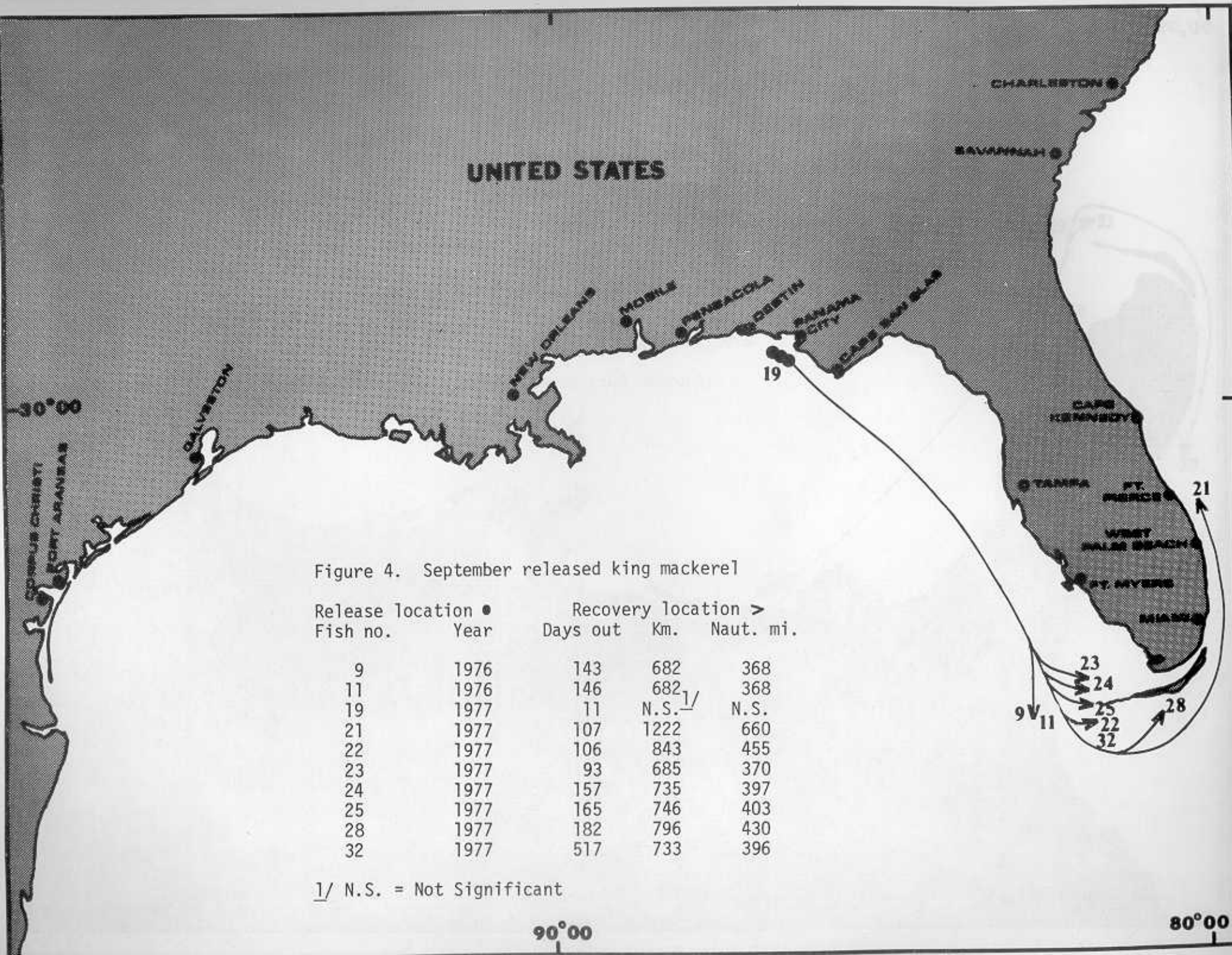


Figure 4. September released king mackerel

Release location • Fish no.	Year	Recovery location > Days out	Km.	Naut. mi.
9	1976	143	682	368
11	1976	146	682	368
19	1977	11	N.S. ^{1/}	N.S.
21	1977	107	1222	660
22	1977	106	843	455
23	1977	93	685	370
24	1977	157	735	397
25	1977	165	746	403
28	1977	182	796	430
32	1977	517	733	396

^{1/} N.S. = Not Significant

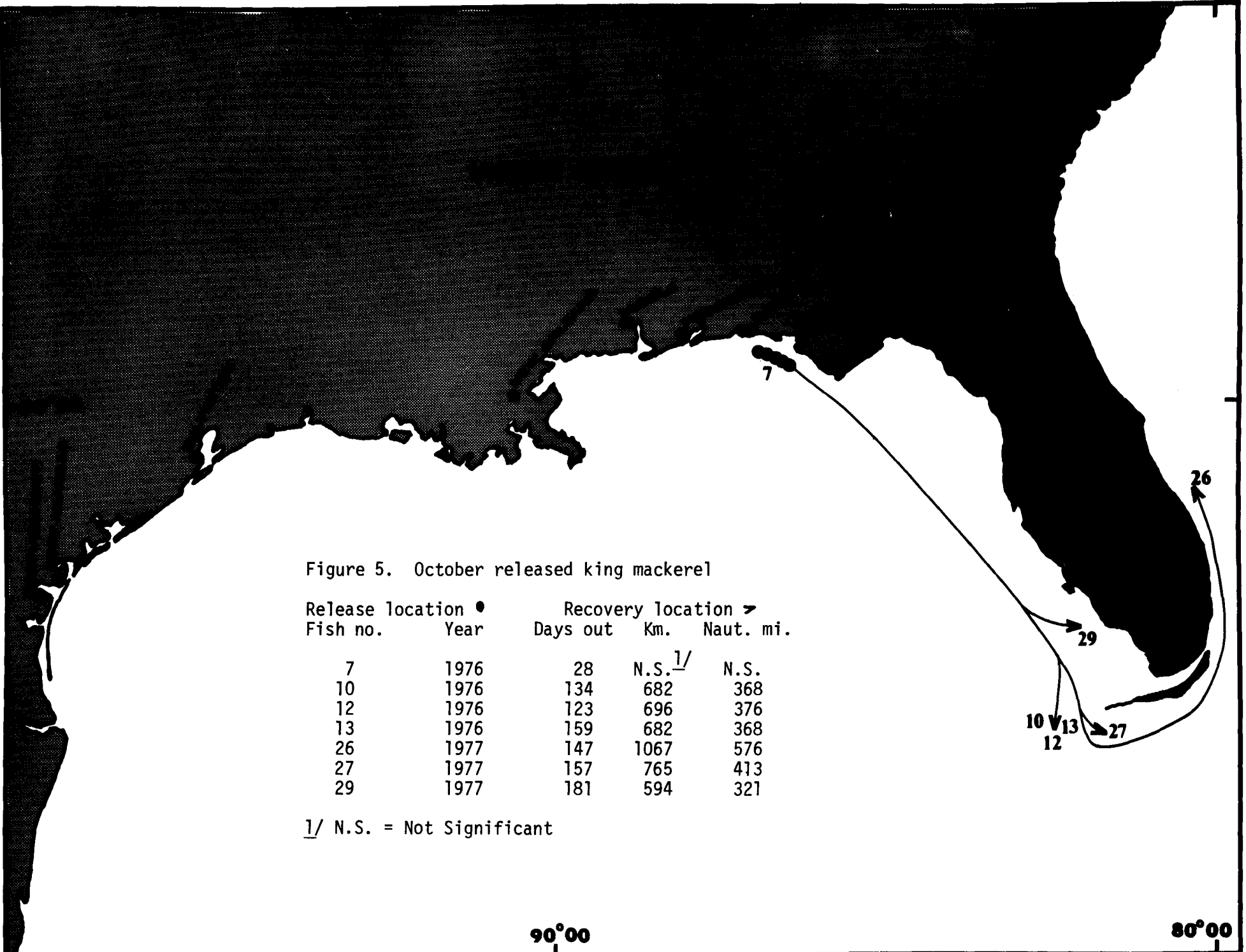


Figure 5. October released king mackerel

Release location ●		Recovery location ➤		
Fish no.	Year	Days out	Km.	Naut. mi.
7	1976	28	N.S. ^{1/}	N.S.
10	1976	134	682	368
12	1976	123	696	376
13	1976	159	682	368
26	1977	147	1067	576
27	1977	157	765	413
29	1977	181	594	321

^{1/} N.S. = Not Significant

CONCLUSIONS

The dart tag used in this study of king mackerel migrations proved to be unreliable for long-term experiments. The adhesive used to bond the two plastic parts eventually failed when exposed to tropical Atlantic ambient air and sea temperatures. Tagging king mackerel by the big-game tagging method with the dart tag also proved to be unsatisfactory because of the critical need to anchor the barb to a pterygiophore. Holding the fish in a water bath and tagging in the dorsal musculature appeared to be a reasonably good approach to reducing handling and tagging mortality.

Waters off Florida's south coasts and off the Keys are important wintering grounds for king mackerel. Evidence from tagging showed conclusively that some fish inhabiting the northern Gulf from Panama City to southern Texas in the summer months ranged into Atlantic waters from the Keys north to Ft. Pierce in the winter months. Most of the Gulf fish, however, appear to over winter on Florida's west coast from the Keys north to Naples. The return of those fish to the northwestern Gulf in the summer was indicated by the recapture of a single tagged fish.

These preliminary results provide direct evidence of an overlap in the range of Atlantic and Gulf king mackerel, but do not confirm or refute the concept of separate stocks. Regardless, the fish are vulnerable to simultaneous exploitation as mixing undoubtedly occurs in Atlantic waters, a matter of vital importance to management of the fishery.

The possibility of the older, larger king mackerel that over-winter in coastal water along the northern Gulf, particularly off Louisiana, comprising a non-migratory stock remains undetermined. An expanded tagging effort would have to be undertaken to make the determination.

ATLANTIC SPANISH MACKEREL

INTRODUCTION

The Atlantic Spanish mackerel (S. maculatus) range from Cape Ann to Brazil and in the Gulf of Mexico (Gulf) according to Jordan, Evermann, and Clark (1930). Briggs (1958) extended the range to the eastern and western Atlantic and the eastern Pacific; in the western Atlantic from Maine to Brazil, and in the northern Gulf. In a recent review of the genus Scomberomorus, Collette and Russo (1979) listed the eastern Atlantic and Brazilian Spanish mackerels as separate species, S. tritor (West African Spanish mackerel) and S. brasiliensis (Serra Spanish mackerel). Further, they described the range of S. maculatus (Atlantic Spanish mackerel) as limited to coastal waters from Cape Cod to Miami and from Florida to Yucatan.

The Atlantic Spanish mackerel is a highly valued food and sport fish. An inhabitant of coastal waters, bays, and estuaries, the fish are readily available to land-based and offshore anglers. Commercial fishermen exploit the fish inshore and offshore with a large variety of gear, although most are caught with runaround gill nets set in offshore waters.

The catch in south Atlantic and Gulf waters in 1970 by sportsmen was estimated to weigh 22,431,000 lbs (Deuel, 1973). In 1975 the catch was estimated to be 9,878,000 lbs, representing a decline of 54% from the 1970 catch. The commercial landings in the same areas showed a simultaneous decline of only 5%, 11,937,000 lbs in 1970 to 11,348,000 lbs in 1975 (Fish. Stat. of the U.S., 1970; Fisheries of the U.S., 1976, 1978).

Table 2. Number of Spanish mackerel tagged and recaptured by year released, 1975-78.

Year	Laboratory								
	Panama City			Port Aransas			Beaufort		
	Tagged	Recaptured	%	Tagged	Recaptured	%	Tagged	Recaptured	%
1976	83	17	20.5	209	0	0.0	0	0	0.0
1976	164	18	11.0	27	1	3.7	50	0	0.0
1977	234	7	3.0	28	1	3.6	23	0	0.0
1978	0	0	0.0	0	0	0.0	0	0	0.0

MATERIAL AND METHODS

The principal method of obtaining Spanish mackerel for tagging was by trolling artificial lures on or near the surface as practiced by local charter boatmen. That method was supplemented by the use of a beach seine at Panama City in the spring of 1977. The fish, after being caught, were taken onboard the catcher boat and tagged as described for king mackerel less than 100 cm. The all-plastic Floy FD-67 anchor tag was used throughout the study.

RESULTS AND DISCUSSIONS

The numbers of Atlantic Spanish mackerel tagged and released by the staffs of the Panama City, Port Aransas, and Beaufort Laboratories and the number of recoveries from all sources are listed in Table 2. Data pertaining to individual recovered fish are summarized in Appendix Table 2. The release/recovery locations and theoretical migratory routes of those fish not recaptured in the immediate release area are illustrated in Figure 7.

The spring migration of Atlantic Spanish mackerel begins in late winter in the eastern Gulf. The fish that over-winter in south Florida waters (Trent and Anthony, 1979) may arrive in the Cape San Blas area as early as late February and in the Panama City area by mid-March. A chronology of the arrival and departure of the 1975 spring migration area is shown in Figure 6. The average daily catch rates were computed from the catch/effort of two boats trolling 4 lines and lures each in the period 11 March - 25 April. The tags were recovered from the commercial gill-net fishery that operates in the area virtually throughout the year.

The catch rate and tag return data indicated the main run began to arrive on approximately 28 March, peaked in the period 2-8 April, and departed by 17 April. A comparatively small population remained or reappeared in the area after 17 April. A catch rate of 1.33 fish per hour was achieved on 22 April and 3 tagged fish were recaptured on 21 May. While in the area the fish were heavily exploited by the commercial fishery with 19.3% of the tagged fish recaptured in that fishery (Table 2).

That the spring migration continues westward along the northern Gulf coast was confirmed by the recapture of tagged fish in the Destin-Alabama Point area each year of the three year study (Figure 7). The 6 recaptured fish traveled from the release sites to the recapture sites at a minimum rate of 1.5 km (0.8 mi.) to 14.3 km (7.7 mi.) per day.

A west to east migration across the northern Gulf is believed to occur in August through October. The catches by northeast Gulf commercial and recreational fishermen during that period are substantially greater than in previous months. The annual migratory cycle supposedly is completed when the fish return to their wintering grounds off south Florida in November and December.

The Campeche-Yucatan area is believed to be the principal wintering grounds of the Atlantic Spanish mackerel inhabiting the western Gulf (David Mendizabal and Javier Vasconcelos, Instituto Nacional de Pesca, Mexico City, personal communications). Commercial fishermen in the Veracruz area anticipate arrival of the fish by mid- to late March from a southerly direction. Similarly, fishermen in the Tampico area expect their arrival by mid- to late April. A single tagged fish released at Port Aransas and later recaptured near Veracruz (Figure 7) strongly suggests that the northward migration ultimately reaches the northwest Gulf coast.

The Atlantic Spanish mackerel referred to above was tagged and released at Port Aransas on 29 September 1974 and subsequently recaptured 37 km

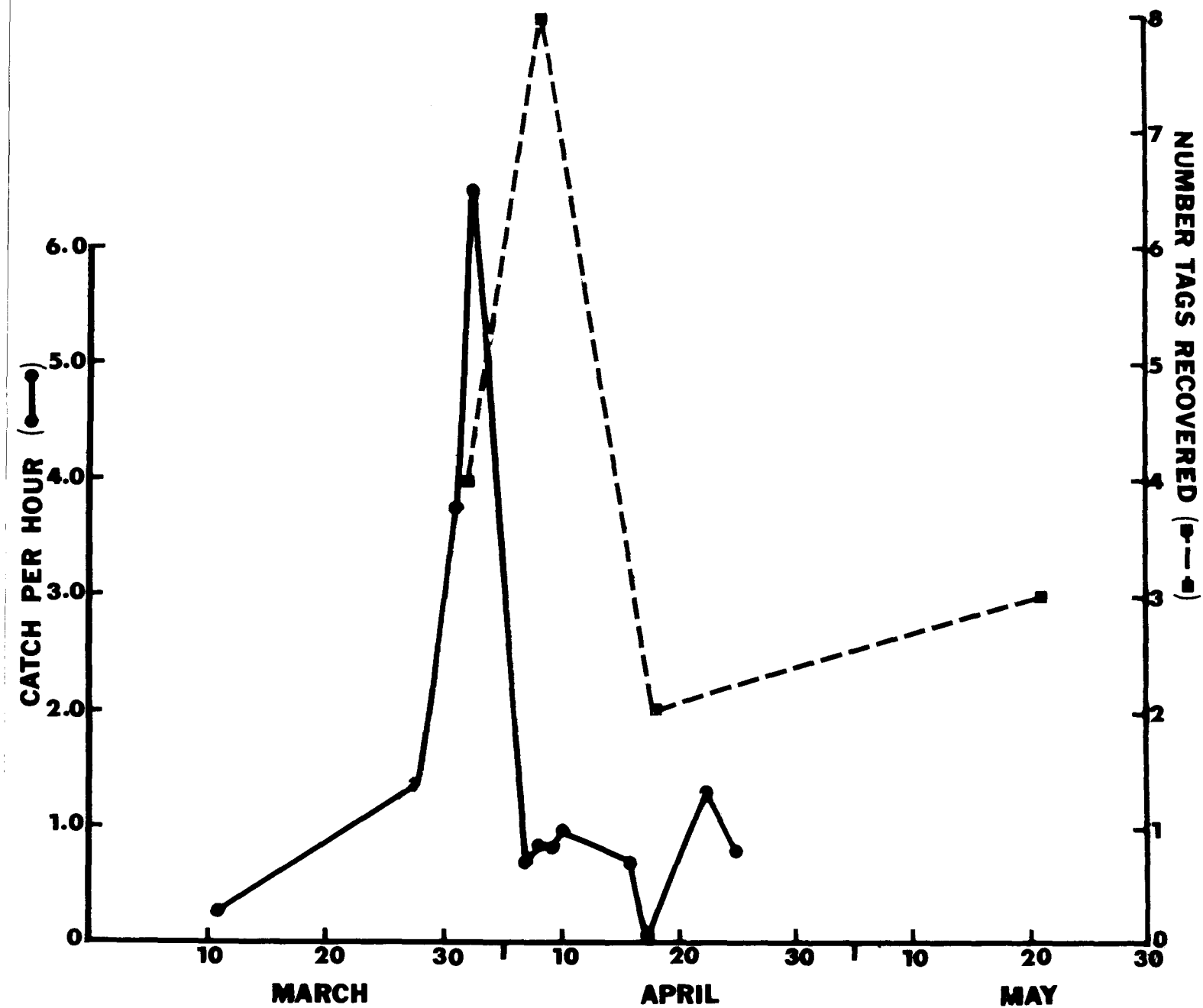
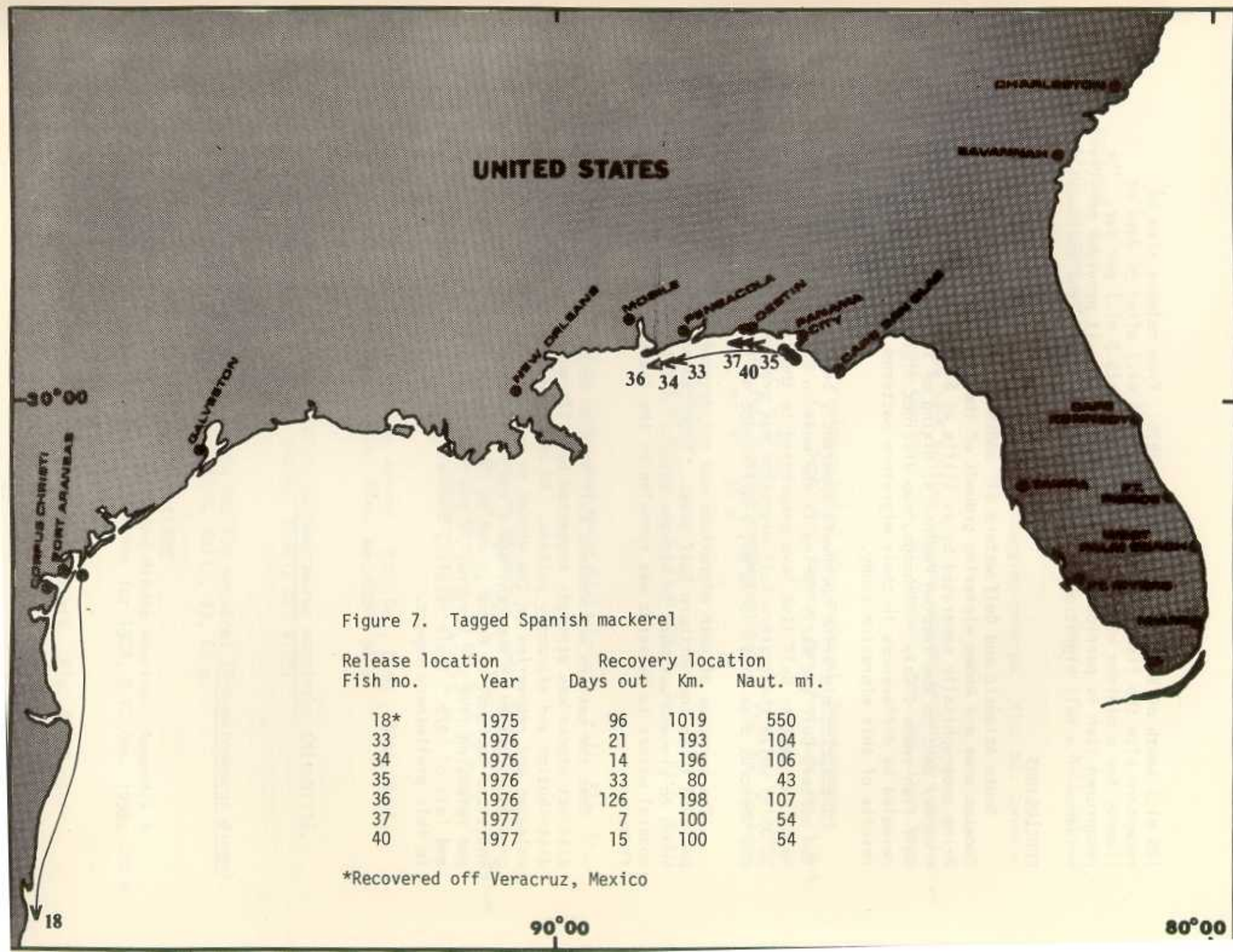


Figure 6. Comparison of Atlantic Spanish mackerel catch rates and tag recoveries in the Panama City area, 11 March - 21 May 1975



(20 mi.) south of Veracruz on 2 January 1976. From release site to recapture site the fish traveled 1,046 km (565 mi.) after 96 days at liberty for a minimum migration rate of 10.9 km (5.9 mi.) per day. The recaptured fish is particularly significant in that it provides positive evidence of a fall migration from the northwest Gulf to the southwest Gulf.

CONCLUSIONS

South Atlantic and Gulf waters off south Florida and off the Campeche-Yucatan area are known wintering grounds of the Atlantic Spanish mackerel. Being geographically separated by as little as 611 km (330 mi.), as measured from Key West to the Yucatan Peninsula, mixing of the eastern and western Gulf fish seems likely. Although, two distinct migratory patterns were revealed by differences in their migratory patterns and from the limited results of this migration study.

The spring migration northward apparently begins in late winter in the eastern Gulf and early spring in the western Gulf. By mid- to late March the eastern Gulf fish have progressed to the Panama City area (lat. 30°05'N) while the western Gulf migration has progressed no farther than the Veracruz area (lat. 19°13'N), a difference of 1,310 km (712 mi.).

The terminus of both migrations was not determined by tagging but is believed to be the northern Gulf coast. From Panama City the fish are known to proceed westward to Alabama waters. A fall migration from Texas coastal waters to Veracruz was revealed by the recapture of a single tagged fish.

That the eastern and western Gulf Spanish mackerel comprise two distinct stocks was strongly suggested by differences in geographic distribution and migratory pattern. An expanded tagging program with releases and recoveries on the winter as well as the summer feeding grounds is needed to substantiate a two stock hypothesis. To that end the Instituto Nacional de Pesca joined in the cooperative study by tagging and releasing fish off Veracruz in the fall of 1978 and again in the spring and fall of 1979. Their results, however, were not available for inclusion in this preliminary report.

LITERATURE CITED

- BAUGHMAN, J.L.
1950. Random notes on Texas fishes, Part II. Tex. J. Sci. 2(2):243-244.
- BEAUMARIAGE, D.S.
1964. Returns from the 1963 Schlitz tagging program. Fla. Bd. Conserv. Mar. Lab. Tech. Ser. No. 43. 33 p.
- BEAUMARIAGE, D.S.
1969. Returns from the 1965 Schlitz tagging program including a cumulative analysis of previous results. Fla. Bd. Conserv. Mar. Res. Lab. Tech. Ser. No. 59. 38 p.
- BEAUMARIAGE, D.S.
1973. Age, growth, and reproduction of king mackerel, Scomberomorus cavalla, in Florida. Fla. Dept. Nat. Resour. Mar. Res. Lab. No. 1:3-4.
- BEAUMARIAGE, D.S., and A.C. WITTICH.
1966. Returns from the 1964 Schlitz tagging program. Fla. Bd. Conserv. Mar. Lab. Tech. Ser. No. 47. 50 p.
- BIGELOW, H.B., and W.C. SCHROEDER.
1953. Fishes of the Gulf of Maine. U.S. Fish Wildl. Serv., Fish. Bull. 43(74):349.
- BRIGGS, J.C.
1958. A list of Florida fishes and their distribution. Bull. Fla. St. Mus. 2(8):287.
- COLLETTE, B.B., and J.L. RUSSO
1979. An introduction to the Spanish mackerels, genus Scomberomorus. In: E.L. Nakamura and H.R. Bullis, Jr. (Eds.). Proceedings: Colloquium on the Spanish and king mackerel resources of the Gulf of Mexico. Gulf States Marine Fisheries Commission, No. 4:3-16.
- DEUEL, D.G.
1973. 1970 salt-water angling survey. U.S. Dep. Comm., NOAA, Natl. Mar. Fish. Serv., Curr. Fish. Stat. No. 6200, 54 p.
- ERDMAN, D.S.
1949. Does the Spanish mackerel, Scomberomorus maculatus (Mitchill), occur throughout the West Indies. Copeia No. 4:301.
- FRY, D.H., and P.M. ROEDEL
1949. Tagging experiments on the Pacific mackerel (Pneumatophorus diego). Calif. Dept. Fish. and Game, Fish. Bull., 73, 64 p.
- JORDAN, D.S., B.W. EVERMANN, and H.W. CLARK
1930. Check list of fishes of North and Middle America. Appendix X Report of the Commissioner of Fisheries for 1928, B.F. Doc. 1055, 670 p.
- MOE, M.A., Jr.
1966. Tagging fishes in Florida offshore waters. Fla. Bd. Conserv. Mar. Lab., Tech. Ser. No. 49, 40 p.

SNEDECOR, G.W., and W.G. COCHRAN.

1967. Statistical methods. Ames Iowa St. Univ. Press 6th ed., 593 p.

SUTHERLAND, D.F.

1977. Catch and catch rates of fishes caught by anglers in the St. Andrew Bay system, Florida and adjacent coastal waters, 1973. U.S. Dep. Comm., NOAA, Natl. Mar. Fish. Serv., NOAA Tech. Rept. NMFS SSRF-708, 9 p.

TRENT, L., and E.A. ANTHONY

1979. Commercial and recreational fisheries for Spanish mackerel, Scomberomorus maculatus. In: E.L. Nakamura and H.R. Bullis, Jr. (Eds.). Proceedings: Colloquium on the Spanish and king mackerel resources of the Gulf of Mexico. Gulf States Marine Fisheries Commission, No. 4:17-32.

U.S. DEPARTMENT OF COMMERCE.

1970. Fishery Statistics of the United States. Stat. Digest No. 73, 489 p.

1976. Fisheries of the United States. Curr. Fish. Stat. No. 6900, 100 p.

1977. Fisheries of the United States. Curr. Fish. Stat. No. 7200, 96 p.

1978. Fisheries of the United States. Curr. Fish. Stat. No. 7500, 112 p.

YAMASHITA, D.T., and K.D. WALDRON

1958. An all-plastic dart-type fish tag. Calif. Fish and Game, 44(4): 311-317.

Appendix Table 1. Summary of king mackerel tag releases and returns, 1975-79.

Fish No.	Tag No.(s)	Release Location - Area	Release Date	F.L. Cm.	Return Location - Area	Return Date	Days Out	Migration	
								Km	Mi
1	P.A.1348	9650W x 2745N Off Port Aransas	8/4/75	-- ^{4/}	9500W x 2900N Off Freeport	8/14/75	11	185	100
2	P.A.1345	9650W x 2745N Off Port Aransas	8/4/75	105	9615W x 2825N Off Port O'Connor	8/16/75	13	93	50
3	P.A.1101	9700W x 2750N Port Aransas Pass	7/2/75	65	9650W x 2745N Off Port Aransas	9/9/75	70	N.S. ^{2/}	N.S. ^{2/}
4	P.C.0544	8552W x 3009N Off Panama City	6/17/76	67	8655W x 3022N Off Navarre Beach	6/24/76	8	117	63
5	P.C.01303	8559W x 3013N Off Phillips Inlet	6/21/76	79	8553W x 3009N Off Florida Beach	7/8/76	18	N.S.	N.S.
6	P.C.05461	8549W x 3008N Off Panama City	6/28/76	69	8551W x 3008N Off Panama City	7/18/76	21	N.S.	N.S.
7	P.C.01433	8550W x 3002N Off Panama City	10/4/76	64	8550W x 3002N Off Panama City	10/31/76	28	N.S.	N.S.
8	P.C.01184	8550W x 3002N Off Panama City	5/21/76	63	8230W x 2440N Off Key West	2/5/77	261	667	360
9	P.C.01394	8548W x 3006N Off Panama City	9/17/76	72	8230W x 2440N Off Key West	2/6/77	143	682	368
10	P.C.01653	8549W x 3009N Off Panama City	10/1/76	64	8230W x 2440N Off Key West	2/11/77	134	682	368
11	P.C.01601	8547W x 3006N Off Panama City	9/20/76	61	8230W x 2440N Off Key West	2/12/77	146	682	368
12	P.C.01445	8557W x 3012N Off Panama City	10/15/76	83	8229W x 2441N Off Key West	2/14/77	123	696	376
13	P.C.05318	8548W x 3008N Off Panama City	10/1/76	75	8230W x 2440N Off Key West	3/8/77	159	682	368
14	P.A.5389	9712W x 2634N Off Port Mansfield	8/21/76	--	8000W x 2600N Off Key West	April 77	200 ^{3/}	1667	900 ^{3/}
15	P.C.14512	8156W x 2611N Off Naples	3/26/77	78	8215W x 2618N Off Sanibel Island	4/7/77	13	N.S.	N.S.
16	P.A.1801	9650W x 2745N Off Port Aransas	6/30/77	72	9700W x 2745N Off Port Aransas	7/10/77	10	N.S.	N.S.
17	P.C.01565	8157W x 2556N Off Naples	3/20/77	67	9702W x 2809N Off Port Aransas	7/10/77	113	1504	812
18	P.C.14603	8616W x 3006N Off Destin	6/23/77	--	8604W x 3014N Off Phillips Inlet	7/10/77	18	N.S.	N.S.

Appendix Table 1. continued

Fish No.	Tag No. (s)	Release Location - Area	Release Date	F.L. Cm.	Return Location - Area	Return Date	Days Out	Migration	
								Km ^{1/}	Mi ^{1/}
19	P.C.14933	8549W x 3009N Off Panama City	9/14/77	63	8548W x 3009N Off Florida Beach	9/24/77	11	N.S. ^{2/}	N.S. ^{2/}
20	P.C.01698	8157W x 2558N Off Naples	3/22/77	67	8039W x 2447N Off Islamorada	12/10/77	264	187	101
21	P.C.14572	8547W x 3007N Off Panama City	9/14/77	63	8007W x 2739N Off Ft. Pierce	12/29/77	107	1222	660
22	P.C.14885	8550W x 3008N Off Panama City	9/15/77	73	8155W x 2426N Off Key West	12/29/77	106	843	455
23	P.C.14988	8550W x 3008N Off Panama City	9/15/77	75	8225W x 2443N Off Key West	12/16/77	93	685	370
24	P.C.09670	8545W x 3004N Off Panama City	9/12/77	--	8222W x 2423N Off Marquesas	2/15/78	157	735	397
25	P.C.14962	8549W x 3009N Off Panama City	9/14/77	70	8146W x 2427N Off Key West	2/25/78	165	746	403
26	P.C.14588	8548W x 3007N Off Panama City	10/5/77	81	8007W x 2708N Off Ft. Pierce	2/28/78	147	1067	576
27	P.C.15328	8545W x 3005N Off Panama City	10/7/77	76	8145W x 2422N Off Key West	3/12/78	157	765	413
28	P.C.14960	8549W x 3009N Off Panama City	9/14/77	79	8105W x 2428N Off Marathon	3/14/78	182	796	430
29	P.C.14578	8548W x 3006N Off Panama City	10/4/77	70	8215W x 2549N Off Naples	4/2/78	181	594	321
30	P.C.14636	9510W x 2834N Off Freeport	7/24/78	--	9446W x 2820N Off Freeport	8/28/78	36	N.S.	N.S.
31	P.C.01819	9510W x 2858N Off Freeport	7/29/78	--	8141W x 2427N Off Key West	1/30/79	186	1424	769
32	P.C.15044	8550W x 3002N Off Panama City	9/21/77	66	8146W x 2426N	2/19/79	517	733	396

^{1/} Shortest route^{2/} N.S. = Not Significant^{3/} Circa^{4/} No data

Appendix Table 2. Summary of Spanish Mackerel Tag Releases and Returns, 1975-77

Fish No.	Tag No(s)	Release Location - Area	Release Date	F.L. Cm.	Return Location - Area	Return Date	Days Out	Migration	
								Km <u>1</u> /	Mil/
1	P.C.05036	8538W x 3004N St. Andrew Bay	4-2-75	33	8538W x 3004N St. Andrew Bay	4-2-75	1	N.S. <u>2</u> /	N.S. <u>2</u> /
2	P.C.05037	8538W x 3004N St. Andrew Bay	4-2-75	39	8538W x 3004N St. Andrew Bay	4-2-75	1	N.S.	N.S.
3	P.C.05040	8538W x 3004N St. Andrew Bay	4-2-75	40	8538W x 3004N St. Andrew Bay	4-2-75	1	N.S.	N.S.
4	P.C.05047	8538W x 3004N St. Andrew Bay	4-2-75	33	8538W x 3004N St. Andrew Bay	4-2-75	1	N.S.	N.S.
5	P.C.05004	8542W x 3006N St. Andrew Bay	3-28-75	35	8538W x 3004N St. Andrew Bay	4-8-75	12	N.S.	N.S.
6	P.C.05023	8543W x 3008N St. Andrew Bay	4-1-75	30	8538W x 3004N St. Andrew Bay	4-8-75	8	N.S.	N.S.
7	P.C.05024	8543W x 3008N St. Andrew Bay	4-1-75	31	8538W x 3004N St. Andrew Bay	4-8-75	8	N.S.	N.S.
8	P.C.05029	8538W x 3004N St. Andrew Bay	4-2-75	32	8538W x 3004N St. Andrew Bay	4-8-75	7	N.S.	N.S.
9	P.C.05031	8538W x 3004N St. Andrew Bay	4-2-75	34	8538W x 3004N St. Andrew Bay	4-8-75	7	N.S.	N.S.
10	P.C.05057	8538W x 3004N St. Andrew Bay	4-7-75	32	8538W x 3004N St. Andrew Bay	4-8-75	2	N.S.	N.S.
11	P.C.05061	8538W x 3004N St. Andrew Bay	4-7-75	35	8538W x 3004N St. Andrew Bay	4-8-75	2	N.S.	N.S.
12	P.C.05062	8538W x 3004N St. Andrew Bay	4-7-75	33	8538W x 3004N St. Andrew Bay	4-8-75	2	N.S.	N.S.
13	P.C.05065	8538W x 3004N St. Andrew Bay	4-8-75	31	8538W x 3004N St. Andrew Bay	4-8-75	1	N.S.	N.S.
14	P.C.05067	8538W x 3004N St. Andrew Bay	4-8-75	31	8538W x 3004N St. Andrew Bay	4-8-75	1	N.S.	N.S.
15	P.C.05020	8543W x 3008N St. Andrew Bay	4-1-75	29	8538W x 3004N St. Andrew Bay	5-21-75	51	N.S.	N.S.
16	P.C.05044	8538W x 3004N St. Andrew Bay	4-2-75	36	8538W x 3004N St. Andrew Bay	5-21-75	50	N.S.	N.S.
17	P.C.05069	8538W x 3004N St. Andrew Bay	4-9-75	35	8538W x 3004N St. Andrew Bay	5-21-75	43	N.S.	N.S.
18	P.A.9727	9700W x 2750N Port Aransas Pass	9-29-75	41	9600W x 1900N So. Veracruz 20 Mi.	1-2-76	96	1019	550

Appendix Table 2. continued

Fish No.	Tag No(s)	Release Location - Area	Release Date	F.L. Cm.	Return Location - Area	Return Date	Days Out	Migration	
								Km ¹ /	Mi ¹ /
19	P.C.05084	8538W x 3004N St. Andrew Bay	3-19-76	31	8538W x 3004N St. Andrew Bay	3-22-76	4	N.S.	N.S.
20	P.C.05087	8544W x 3007N St. Andrew Bay	3-19-76	37	8543W x 3008N St. Andrew Bay	3-24-76	6	N.S.	N.S.
21	P.C.05091	8538W x 3004N St. Andrew Bay	3-24-76	33	8543W x 3008N St. Andrew Bay	3-24-76	1	N.S.	N.S.
22	P.C.05105	8543W x 3008N St. Andrew Bay	3-25-76	34	8543W x 3008N St. Andrew Bay	4-2-76	9	N.S.	N.S.
23	P.C.05144	8543W x 3008N St. Andrew Bay	3-31-76	32	8543W x 3008N St. Andrew Bay	4-2-76	3	N.S.	N.S.
24	P.C.05111	8543W x 3008N St. Andrew Bay	3-25-76	31	8543W x 3008N St. Andrew Bay	4-5-76	12	N.S.	N.S.
25	P.C.05243	8531W x 2958N Off Crooked Island	4-8-76	42	8538W x 3004N St. Andrew Bay	4-12-76	5	N.S.	N.S.
26	P.C.05249	8538W x 3004N St. Andrew Bay	4-15-76	42	832W x 3000N Crooked Island Sd.	4-18-76	4	N.S.	N.S.
27	P.C.05246	8531W x 2958N Off Crooked Island	4-14-76	31	8532W x 3000N Crooked Island Sd.	4-18-76	5	N.S.	N.S.
28	P.C.05403	8542W x 3006N St. Andrew Bay	4-15-76	34	8543W x 3008N St. Andrew Bay	4-20-76	6	N.S.	N.S.
29	P.C.05196	8538W x 3004N St. Andrew Bay	4-14-76	33	8538W x 3004N St. Andrew Bay	4-21-76	8	N.S.	N.S.
30	P.C.05402	8542W x 3006N St. Andrew Bay	4-15-76	34	8544W x 3007N Off Shell Island	4-23-76	9	N.S.	N.S.
31	P.C.05235	8531W x 2958N Off Crooked Island	4-8-76	39	8542W x 3006N St. Andrew Bay	4-23-76	16	N.S.	N.S.
32	P.C.05160	8543W x 3008N St. Andrew Bay	4-1-76	33	8543W x 3008N St. Andrew Bay	4-29-76	30	N.S.	N.S.
33	P.C.05237	8531W x 2958N Off Crooked Island	4-8-76	--	8734W x 3016N Perdido Pass	4-28-76	21	200	108
34	P.C.05401	8542W x 3006N St. Andrew Bay	4-15-76	45	8739W x 3015N Off Gulf Shores	4-28-76	14	189	102
35	P.C.05157	8543W x 3008N St. Andrew Bay	3-1-76	39	8625W x 3023N Off Destin Beach	5-2-76	33	74	40

Appendix Table 2. continued

Fish No.	Tag No. (s)	Release Location - Area	Release Date	F.L. Cm.	Return Location - Area	Return Date	Days Out	Migration	
								Km ^{1/}	Mi ^{1/}
36	P.C.05165	8543W x 3008N St. Andrew Bay	4-1-76	50	8733W x 3016N Alabama Point	8-4-76	126	176	95
37	P.C.05278	8543W x 3008N St. Andrew Bay	4-5-77	29	8542W x 3008N St. Andrew Bay	4-7-77	3	N.S.	N.S.
38	P.C.05372	8536W x 3003N Off Crooked Island	5-7-77	39	8630W x 3023N Off Destin Beach	5-13-77	7	100	54
39	P.C.20061	8536W x 3003N Off Crooked Island	5-7-77	41	8524W x 2952N Cape St. Joe	5-18-77	12	N.S.	N.S.
40	P.C.20038	8536W x 3003N Off Crooked Island	5-7-77	38	8543W x 3007N Off Shell Island	5-20-77	14	N.S.	N.S.
41	P.C.20045	8536W x 3003N Off Crooked Island	5-7-77	43	8630W x 3023N Off Destin Beach	5-27-77	15	100	54
42	P.A.9173	9700W x 2750N Port Aransas Pass	5-12-77	23	9700W x 2755N Aransas Bay	6-14-77	33	N.S.	N.S.
43	P.C.06503	8543W x 3008N St. Andrew Bay	5-2-77	--	8543W x 3007N West Pass	6-17-77	47	N.S.	N.S.
44	P.C.05525	8536W x 3003N Off Crooked Island	5-19-77	36	8533W x 3001N Crooked Island Sd.	6-16-77	29	N.S.	N.S.

^{1/} Shortest route^{2/} N.S. = Not Significant